Plant-earthworm interactions alter copper availability in the rhizosphere

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Organism activities in soil are able to alter drastically physical-chemical properties, such as pH and dissolved organic matter (DOM) in the bio-influenced area such as rhizosphere for plants and drilosphere for earthworms. These modifications may drive trace element (TE) availability in soil and their bioavailability to soil organisms but with no consistent trends as shown by a literature overview. In this work we studied the effects of plant-earthworm interactions on the copper (Cu) availability in rhizosphere and its consequences on Cu phytoavailability in soils receiving either mineral fertilizers or organic inputs.

Plant-earthworm interactions were studied with the RHIZOtest, a biotest that enables to grow plants with their roots in contact with the soil layer (considered as the rhizosphere) but not prenetrating it. The RHIZOtest was deployed here in an original manner: (i) without plant and earthworm (i.e. bulk soil), (ii) with plants (*Festuca arrundinaceae*) only (i.e. rhizosphere), (iii) with epi-endogeic earthworms (*Dichogaster saliens*) only (i.e. drilosphere), and (iv) with both plants and earthworms (i.e. rhizo-drilosphere). Two soil samples from the same decadal field experiment were studied, one amended with mineral fertilizers that led to a strongly acidic pH (5.0) and a low organic carbon content (2.0 %) and the other amended with cow slurries that led to a ca. neutral pH (6.5) and much higher organic carbon content (2.9 %). In order to study the pH as a key parameter, the pH was manipulated and controlled in the rhizosphere, drilosphere, and rhizo-drilosphere either by favoring alkalization or by maintaining the initial bulk-soil pH. Copper availability was determined in bulk soils, rhizospheres, drilospheres and rhizo-drilospheres following (i) a kinetic approach based on the diffusive gradient in thin films (DGT) and (ii) an equilibrium approach based on the measurements of total Cu concentration and Cu^{2+} activity in soil solution. The drivers of Cu speciation in soil solution were assessed by modelling using the windermere humic aqueous model (WHAM). Copper phytoavailability was determined by estimating Cu uptake flux in plants.

Results showed that plants and earthworms respectively increased rhizosphere and drilosphere pH when the bulk-soil pH was initially strongly acidic, and decreased rhizosphere and drilosphere DOM concentration. Overall, such physical-chemical changes in the rhizosphere and the drilosphere led to a decrease in Cu availability compared to the initial bulk soil. Results of the biotests are discussed taken into account the hypothesis that plants and earthworms act synergistically to further reduce Cu availability in the rhizo-drilosphere.